Measurement of Elliptic Flow for High pT charged hadron at RHIC-PHENIX

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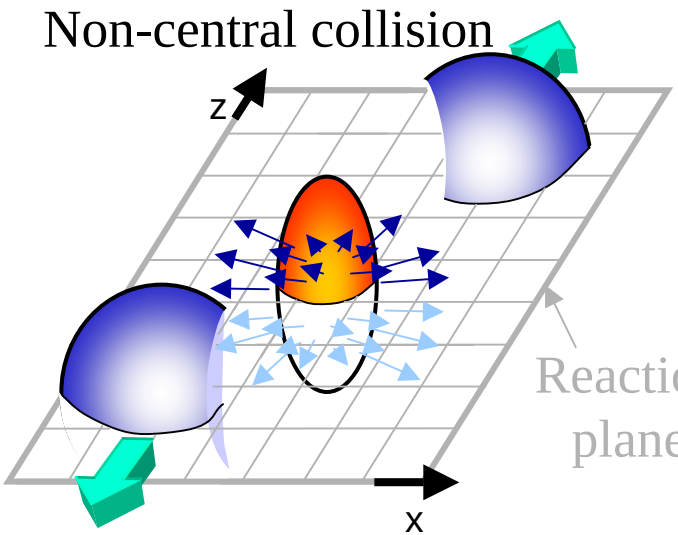
Collaborations

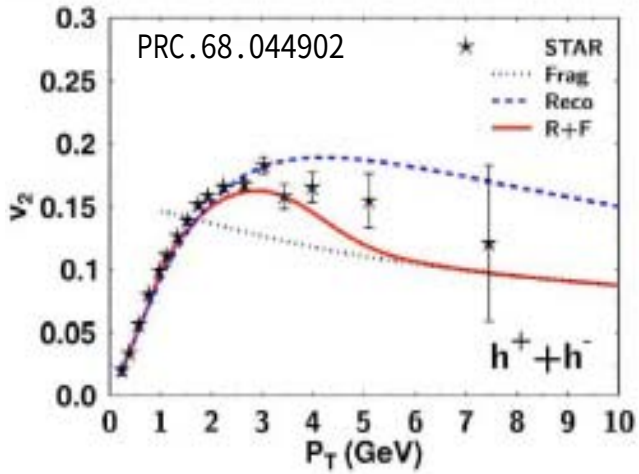
12 Countries; 58 Institutions; 480 Participants*

Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	Rikkyo University, Tokyo, Japan
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund
USA	Abilene Christian University, Abilene, TX
	Brookhaven National Laboratory, Upton, NY
	University of California - Riverside, Riverside, CA
	University of Colorado, Boulder, CO
	Columbia University, Nevis Laboratories, Irvington, NY
	Florida State University, Tallahassee, FL
	Florida Technical University, Melbourne, FL
	Georgia State University, Atlanta, GA
	University of Illinois Urbana Champaign, Urbana-Champaign, IL
	Iowa State University and Ames Laboratory, Ames, IA
	Los Alamos National Laboratory, Los Alamos, NM
	Lawrence Livermore National Laboratory, Livermore, CA
	University of New Mexico, Albuquerque, NM
	New Mexico State University, Las Cruces, NM
	Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
	Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

*as of January 2004

Elliptic Flow(V_2)





Low p_T
- Hydrodynamical behavior
- Pressure gradient

High p_T
- Parton energy loss in the medium. (jet quenching)

Initial anisotropy in coordinate space is transferred into momentum space in the final stage.
→Intensity of Elliptic Flow (V2) of emitted hadrons at non-central collision

$$\frac{dN}{d\phi} \propto 1 + 2V_2 \cos 2(\phi - \Phi_{RP})$$

ϕ : azimuthal angle of detected particles
ψ : azimuthal angle of reaction plane

RHIC-PHENIX experiment

<RHIC --relativistic heavy ion collider>

- @BNL in U.S.A.
- Collision energy : Up to $\sqrt{S_{NN}}$ = 200 GeV in Au+Au
- Au+Au collision in 2003~2004 (= RUN4)

<PHENIX – one of the experiments at RHIC>

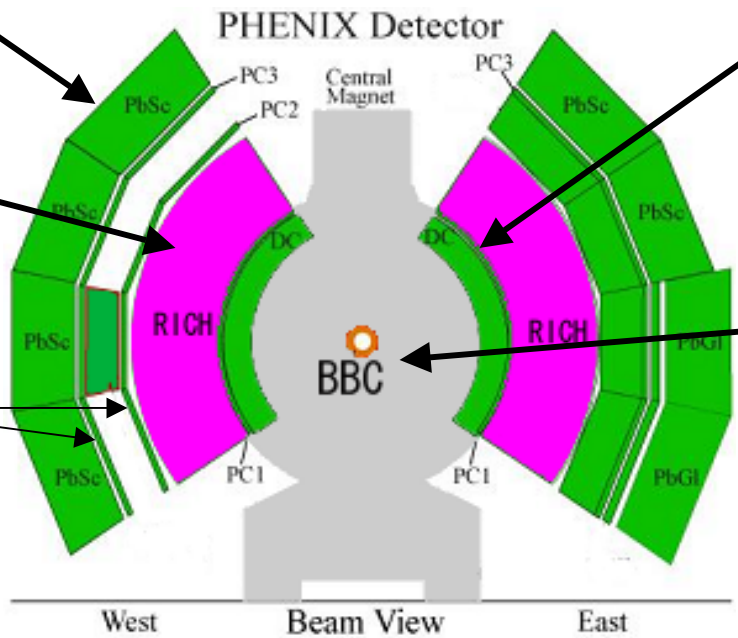
EMCAL
for Energy cut

RICH
for electron BG rejection

PC2+PC3
for BG rejection

DC + PC1
for good track selection and to determine p

BBC
to determine reaction plane



<Methods for back ground rejection>

<Method 1 ‘‘‘energy cut> --- 142million events

- |PC3sdphi |<2.0σ ,|PC3sdz| <2.0σ , |EMCsdphi|<2.0σ , |EMCsdz|<2.0σ
- E/p cut

<Method 2 ‘‘‘geometrical cut> --- 76 million events

- |PC2sdz| <2.0σ, |PC3sdz| <2.0σ , |PC2sdphi-PC3sdphi| <2.0σ , brphi=|PC2sdphi+PC3sdphi|/2<2.5σ (for signal)
- using 4.0σ <|PC2sdphi+PC3sdphi|/2<8 σ(for BG)
- Requiring hit on EMC

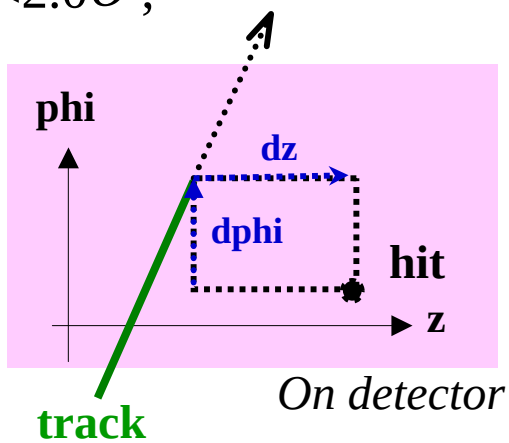
[Method 2-1] For n0=0 (RICH not fired) particles

→ scaling brphi distribution at pT>10GeV

[Method 2-2] For 0<n0<=4 (RICH fired)

→ scaling the shape of brphi distribution at n0>4.

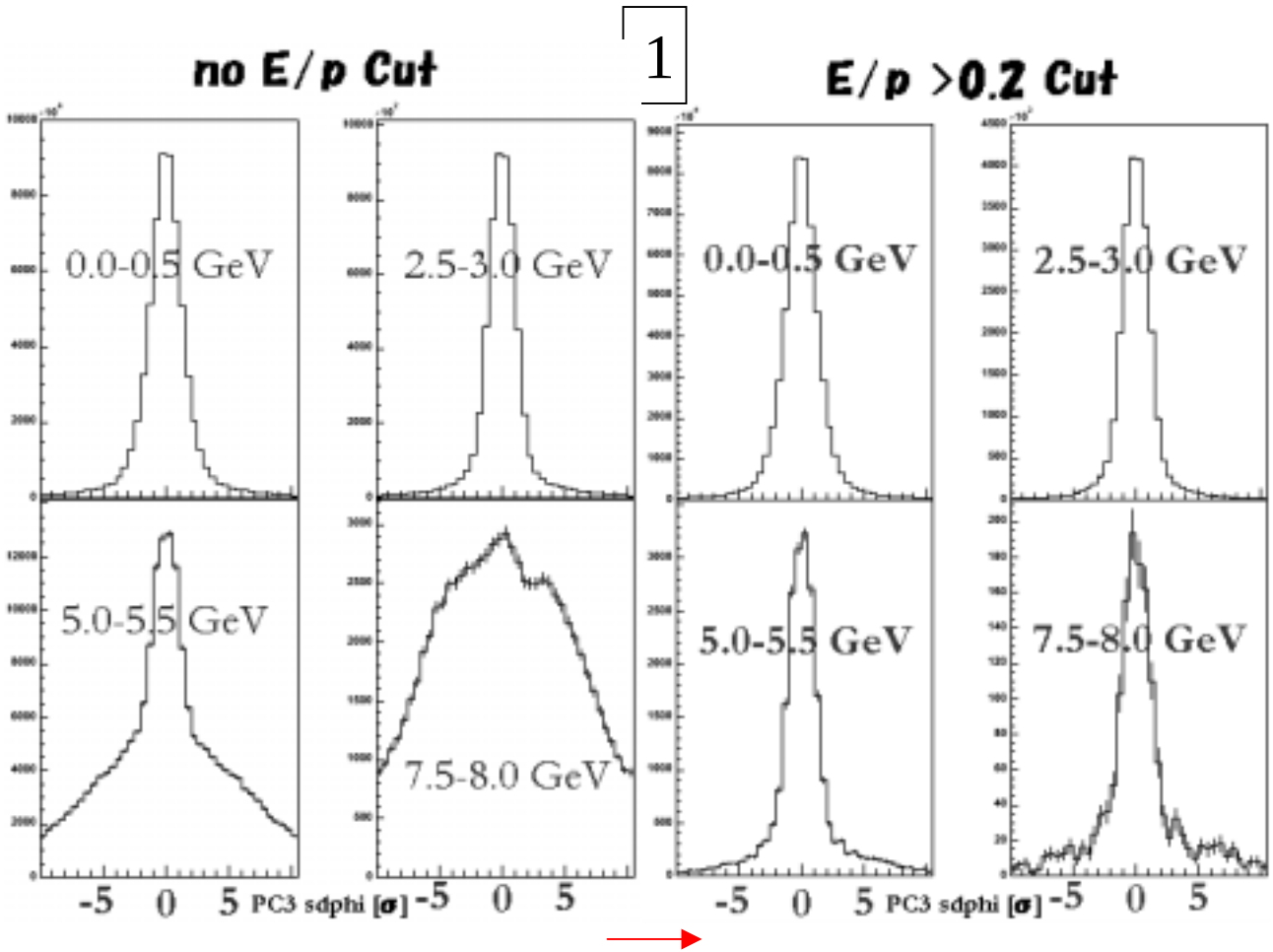
Match the heights of BG to All at 4<brphi<8

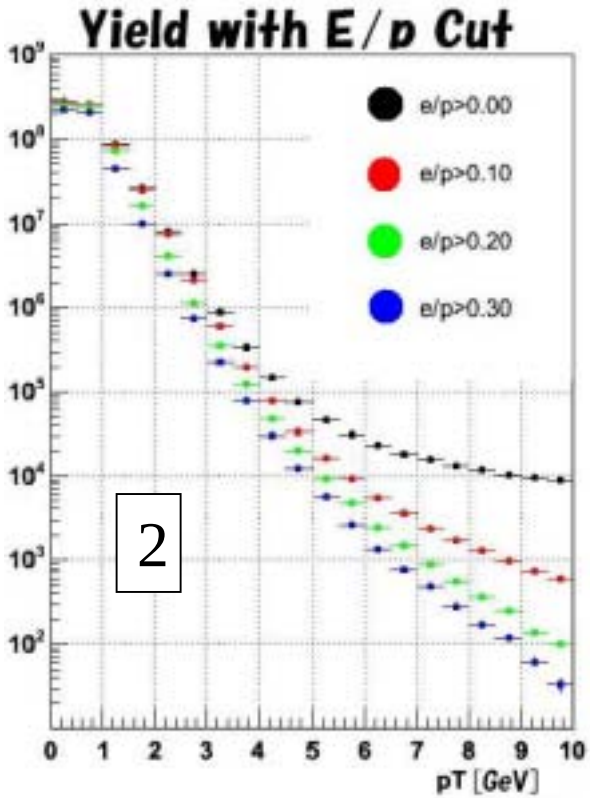


n0 is the # of fired PMTs at **RICH**

<Method 1>

1. PC3 sdphi distribution at different pT region
2. Yield vs pT at different e/p cut



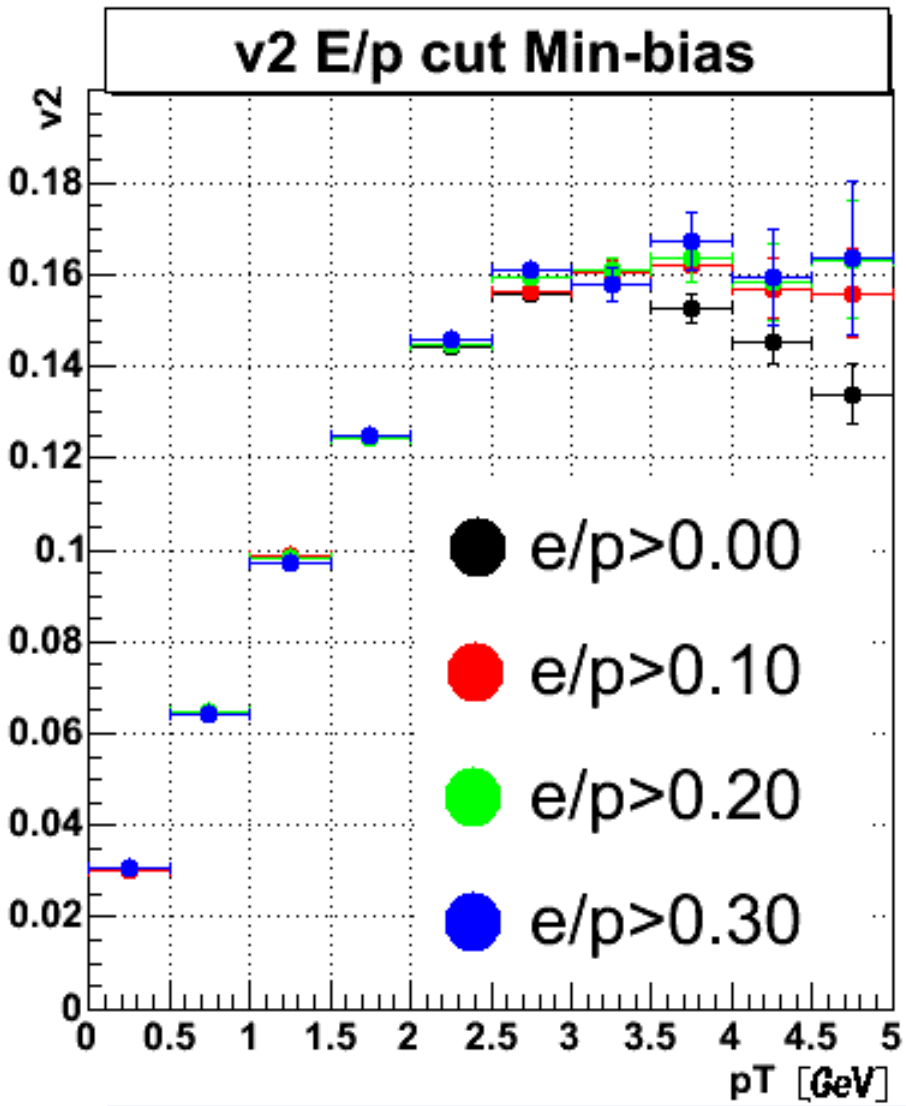


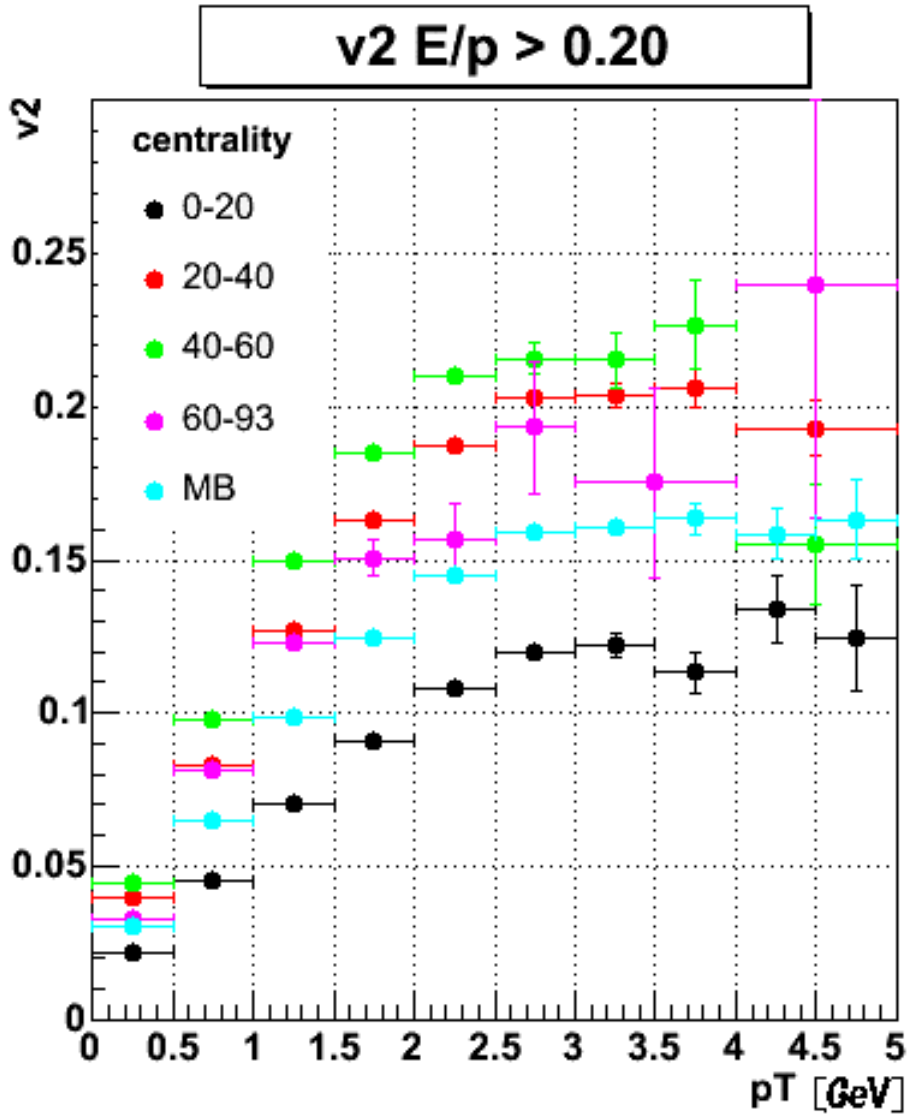
E/p>0.2 ~ cut can reject BG.

E/p>0.2 cut

PC3 [dphi/ **σ**]

Charged hadron v2 by Method1





V_2 with E/p >0.2 is almost same as V_2 with E/p >0.3

<Method2>

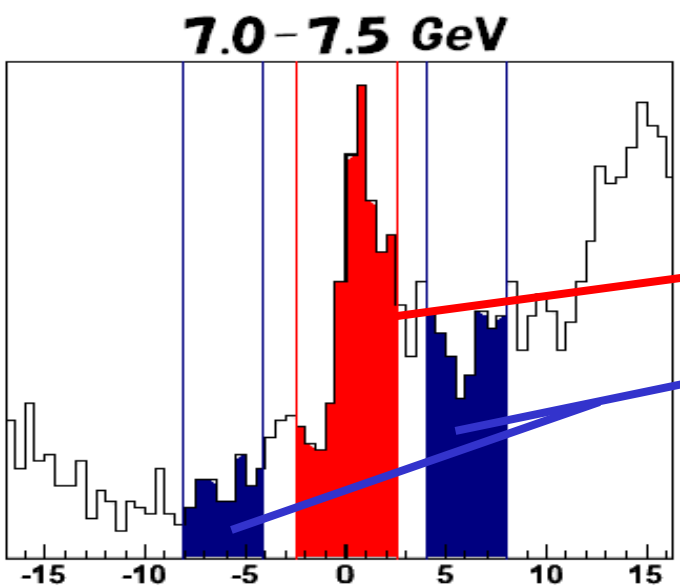
Separate the particles to

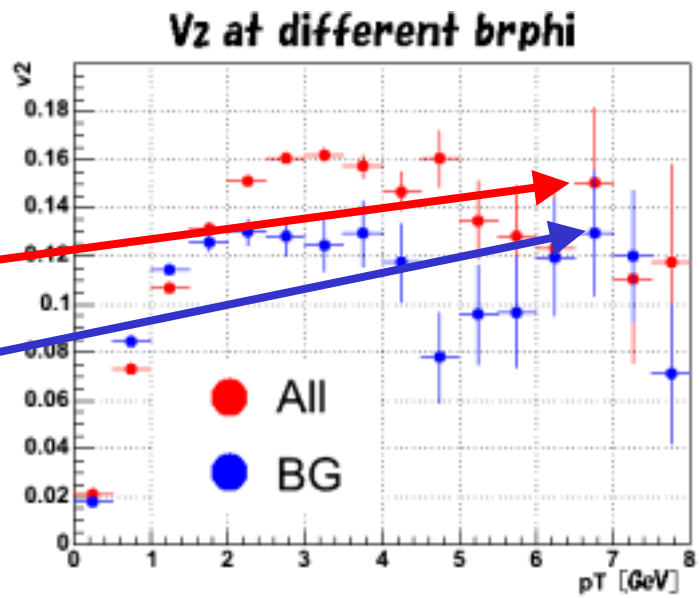
RICH not fired (n0=0), RICH fired (0<n0<=4) and RICH fired(n0>4)

1. n0=0 --- signal + decay BG
2. 0<n0<=4 --- signal(mostly pion) + e BG
3. n0>4 --- e BG

"all" comes from |pc2sdphi+pc3sdphi|/2 <2.5

"background" comes from 4.0<|pc2sdphi+pc3sdphi| <8.0

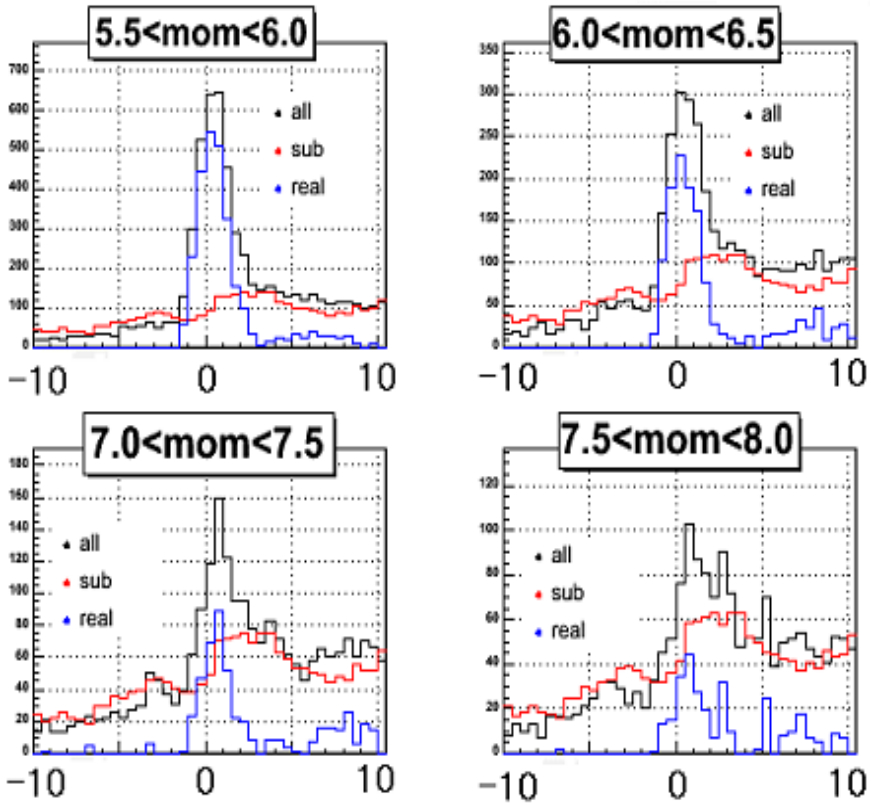




<Method 2-1>

1. RICH not fired (n0=0 --- signal +decay BG)

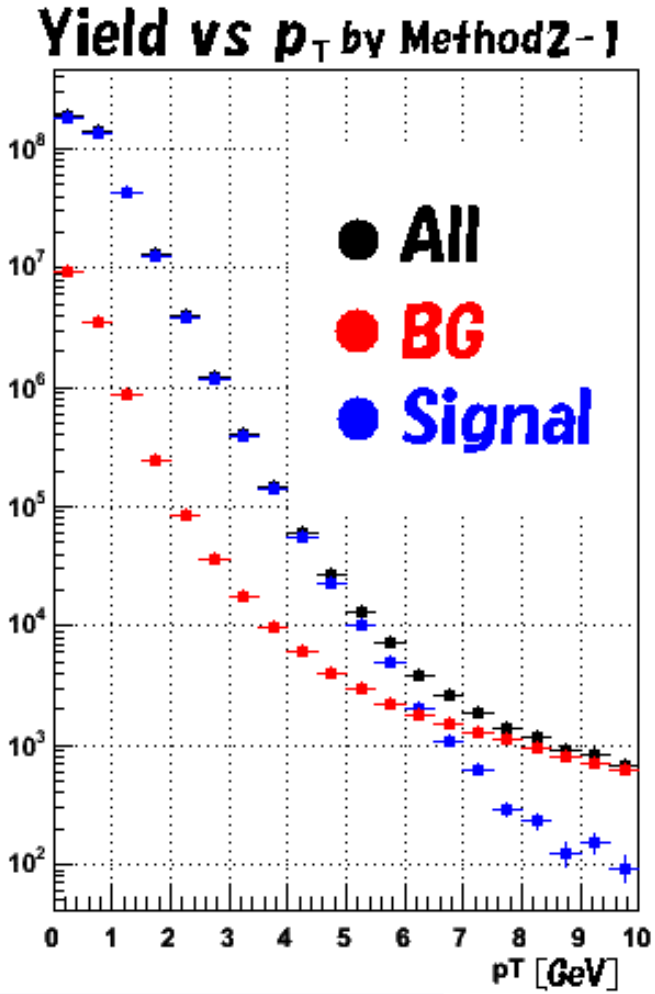
brphi distributions [Charge + Min-Bias]



•Black- all

•Red – BG (Scaling with distribution at pT>10GeV)

•Blue- signal (all-BG)



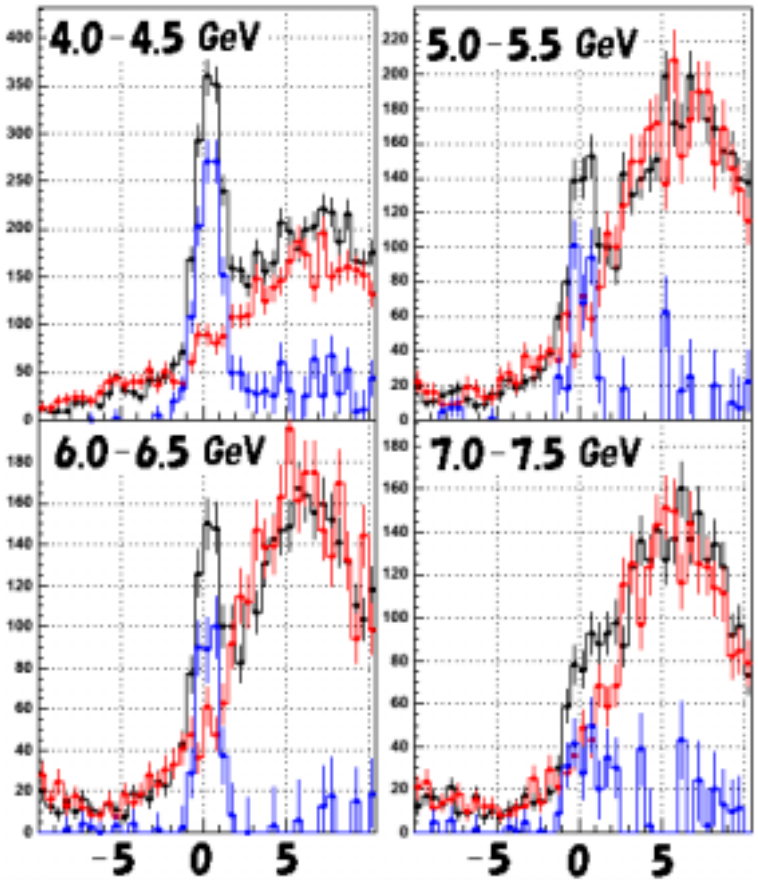
Match the heights of BG to All at 4<brphi<8

Method 2-1 rejects BG for the particles firing RICH.

<Method2-2>

2. RICH fired (0<n0<4 --- signal + electron BG)

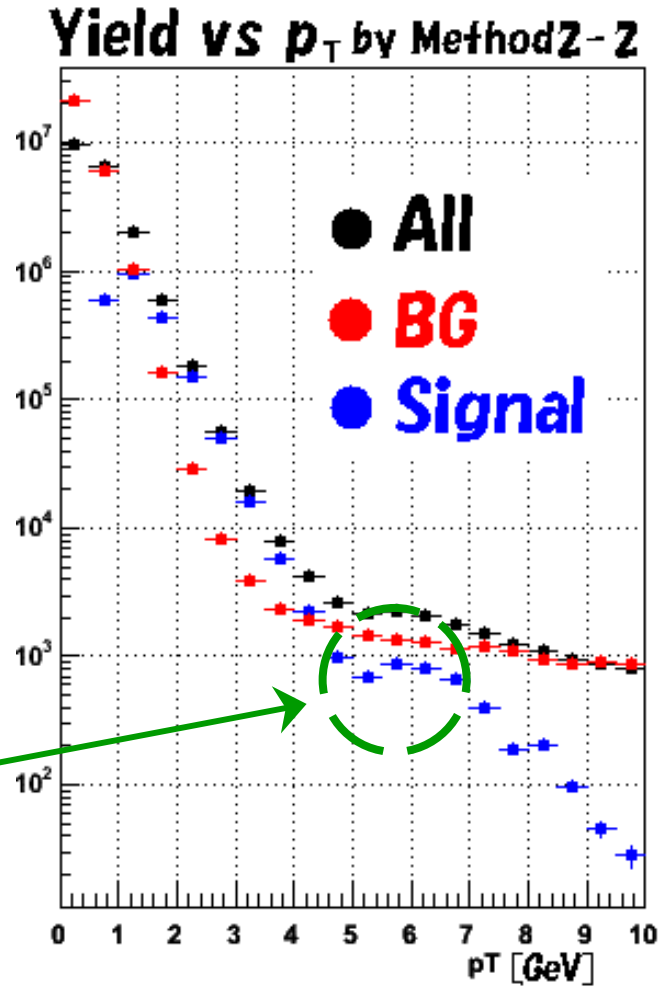
brphi distributions [Charge + Min-Bias]



Match the heights of BG to All at 4<brphi<8

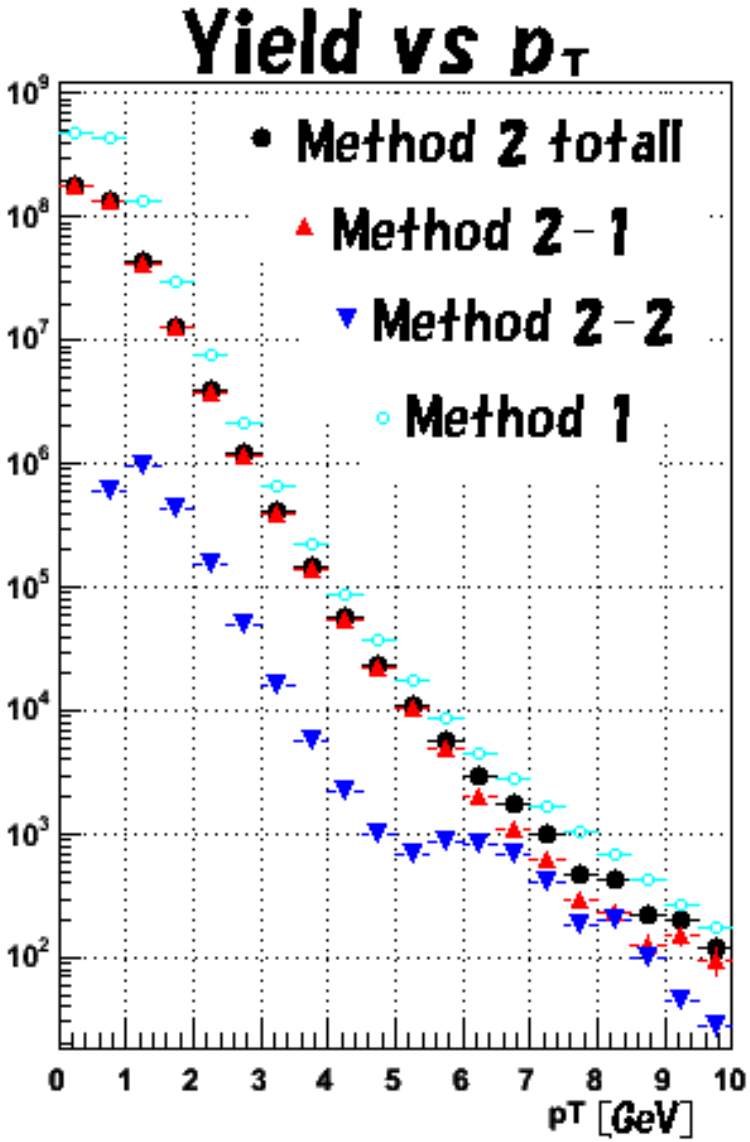
- Black- All
- Red – BG (obtained by scaling distribution of n0>4 in each pT bin)
- Blue- Signal (All-BG)

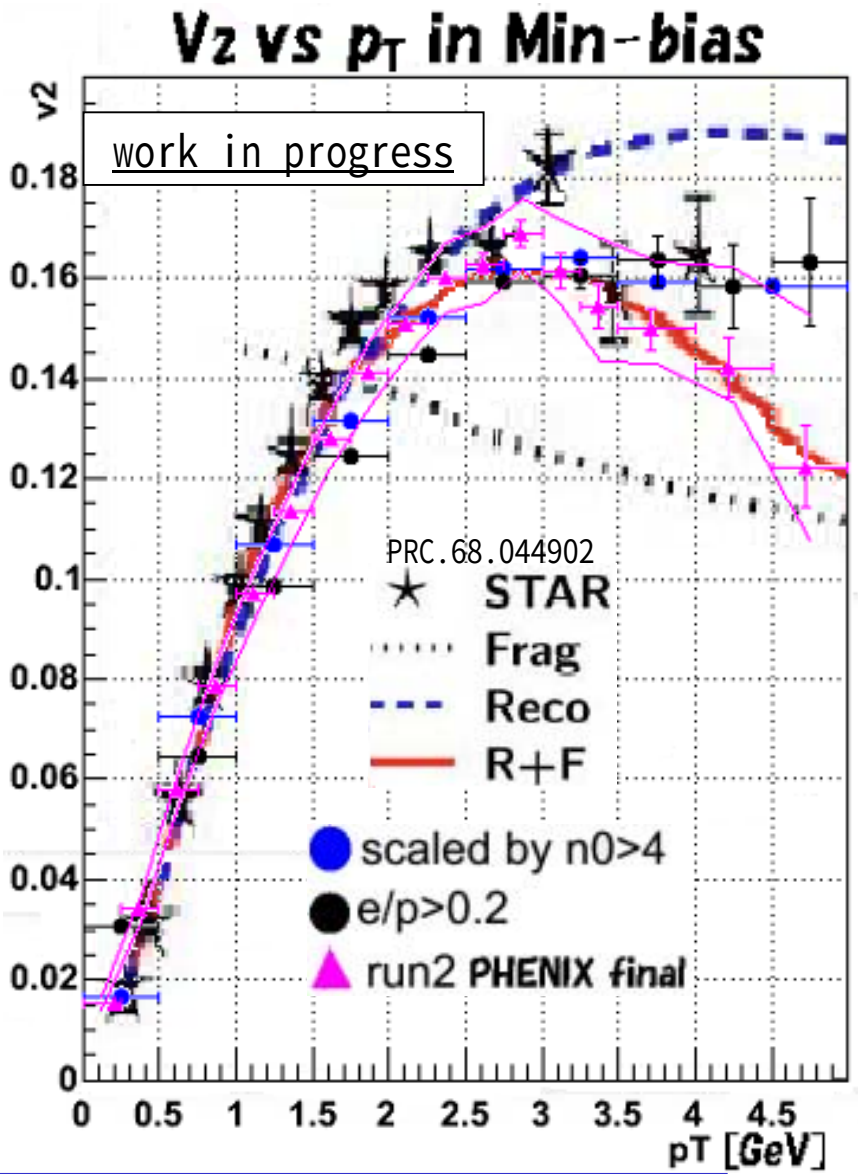
Pion starts to fire RICH



Method 2-2 rejects BG for the particles firing RICH.

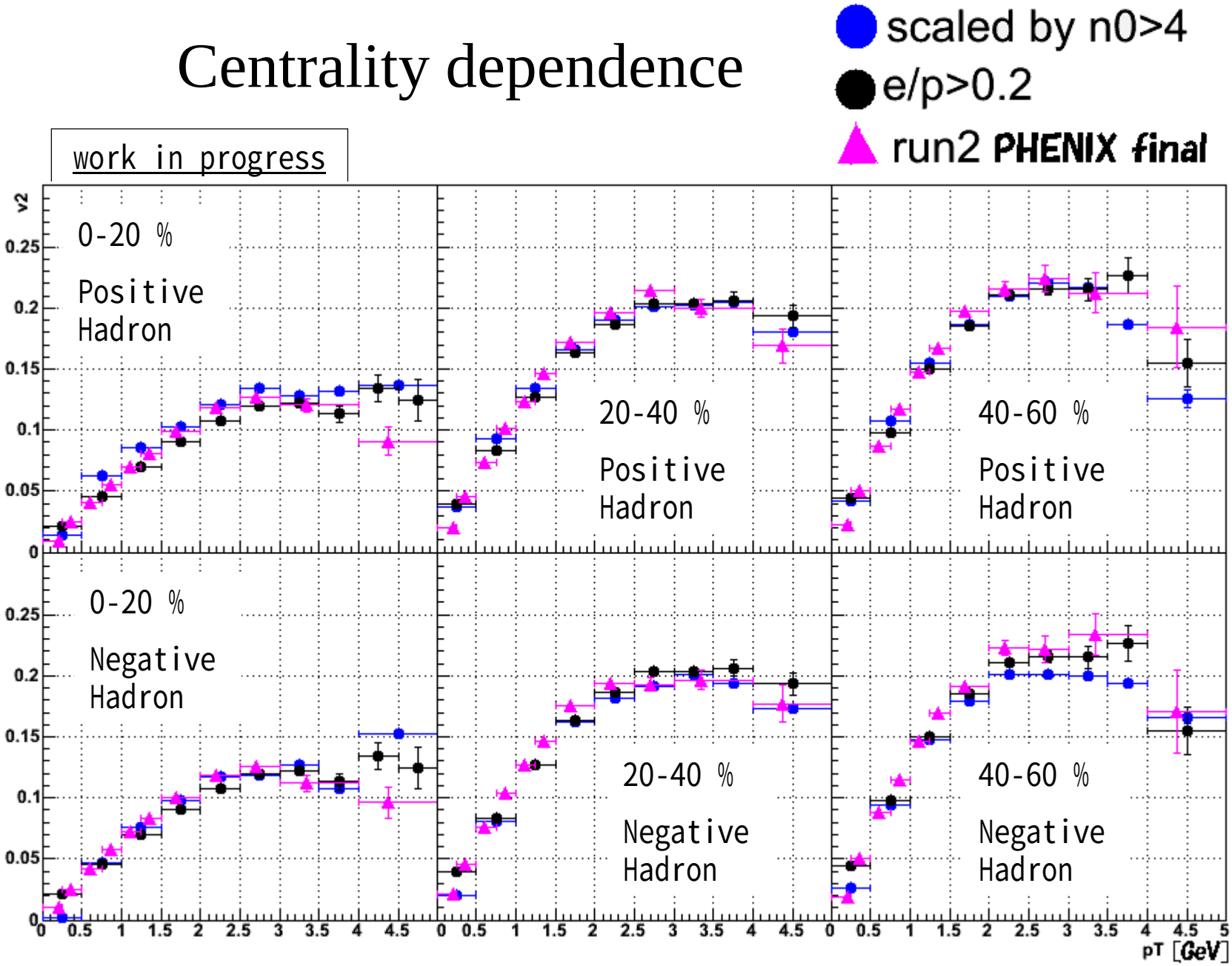
Comparison of the results





All methods have good agreement to Run2 results

Centrality dependence



Summary and Next step

<Summary>

- Two Methods can reject BG of high p_T charged Hadrons to get V_2.
- Charged hadron V_2 of Run4 data is obtained by those methods.
- The results show good agreement with the run2 results.

<Next Step>

- These two methods will be applied to higher pT range (~8GeV) to get V_2.

Back Up

From here

azimuthal anisotropy

$$\frac{dN}{d\phi} = N\frac{1}{\pi}(1+\sum_{n=1}^{\infty} 2v_n \cos[n(\phi-\Psi)]) \qquad (\text{n} = 1,2,\ldots)$$

ϕ : azimuthal angle of each PMT (BBC)

Ψ : azimuthal angle of reaction plane

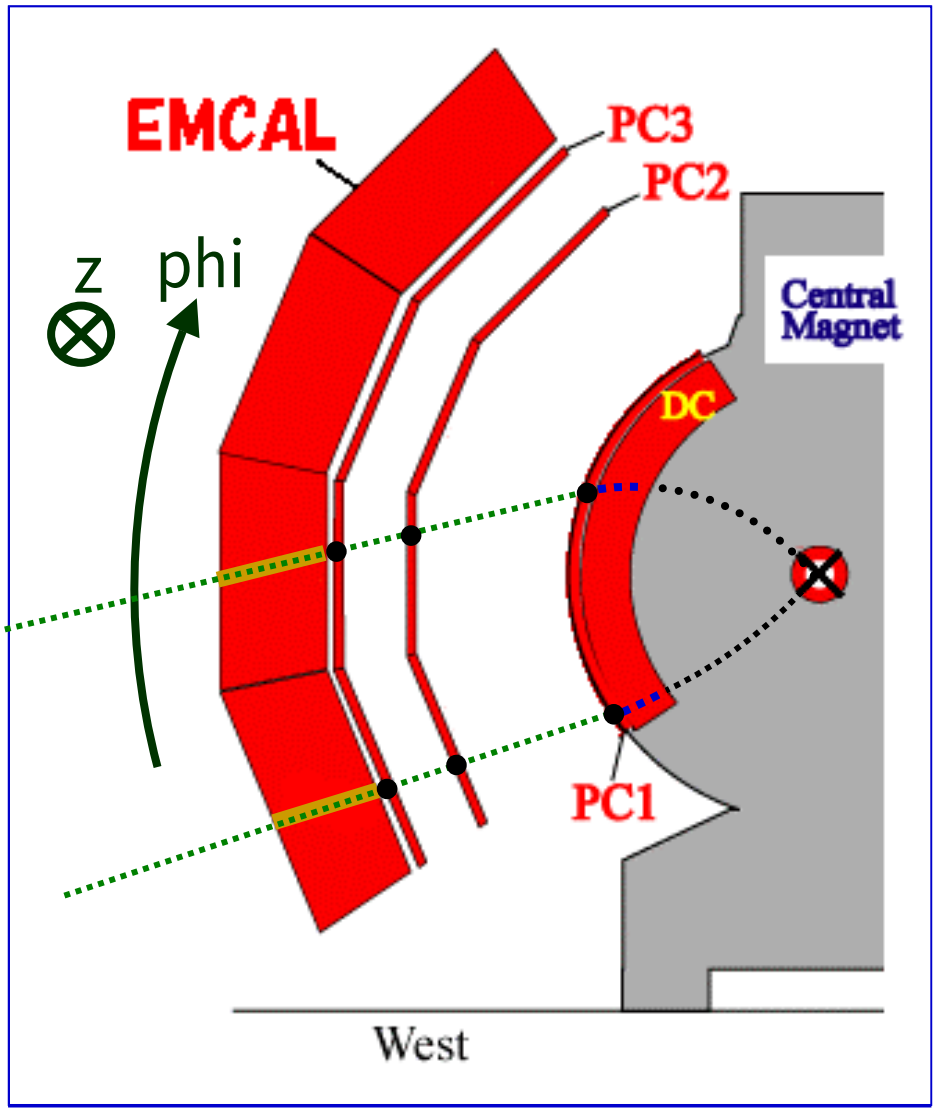
v_n : anisotropy parameter

$$v_n = \frac{v_n^{measured}}{resolution}$$

$$resolution = <\cos[n(\Psi_{measured} - \Psi_{true})]> \sim \sqrt{<\cos[n(\Psi_A - \Psi_B)]>}$$

$\Psi_{A,B}$: reaction plane determined for each sub sample.

軌跡の再構成

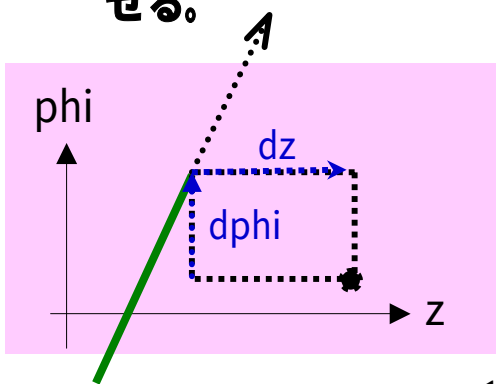


1. DCで検出された荷電粒子が、必ず衝突点からきているものとして、軌跡を再構成

→ 運動量を計算

2. その運動量ごとの磁場の影響を考慮して、残りの軌跡を描く

3. 各検出器で一番近いヒットを組み合わせる。

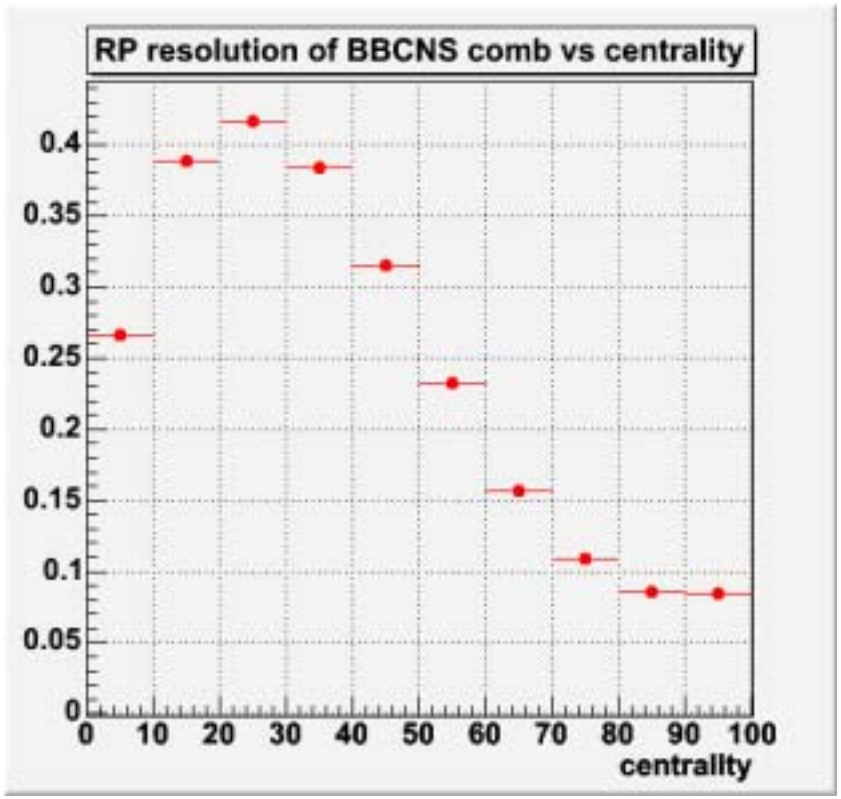


<Data set>

- Run4
- 142million events for method 1
- 76 million events for method 2

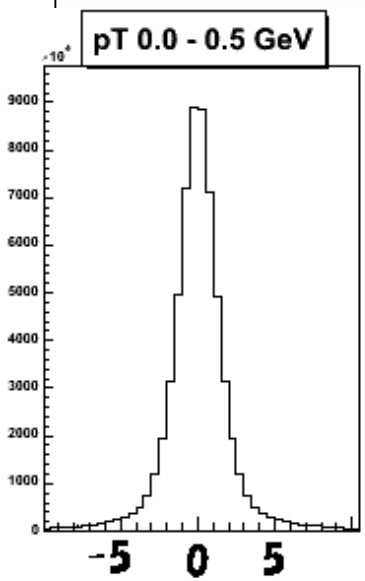
<Reaction Plane for measurement of V2>

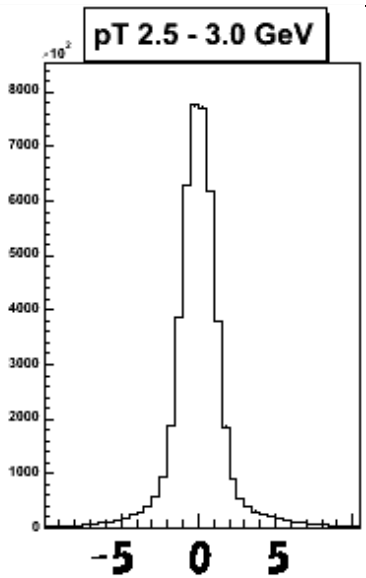
- Use Reaction Plane re-calibrate module (which is made by H. Masui).
- Use the information from combined BBC North & South.
- Calculate the resolution depending on Centrality (0- 93%).

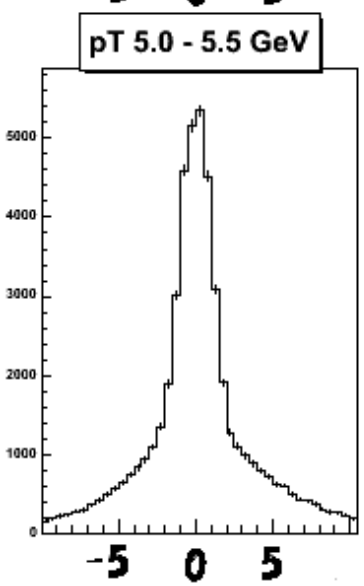


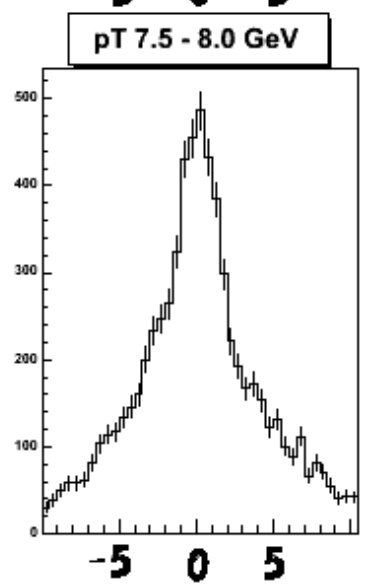
Method 1 E/p > 0.1 or 0.3

Brphi distribution with E/p>0.1

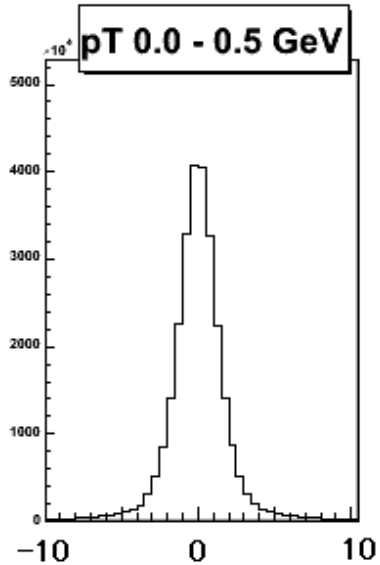


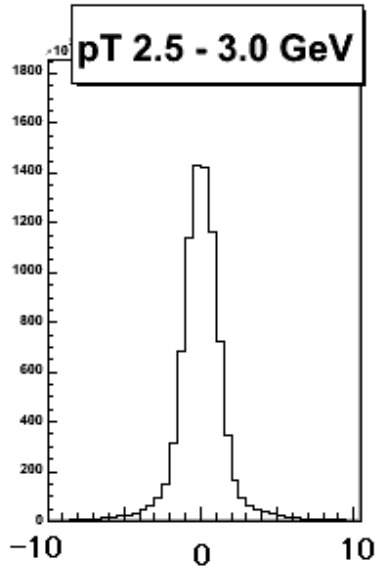


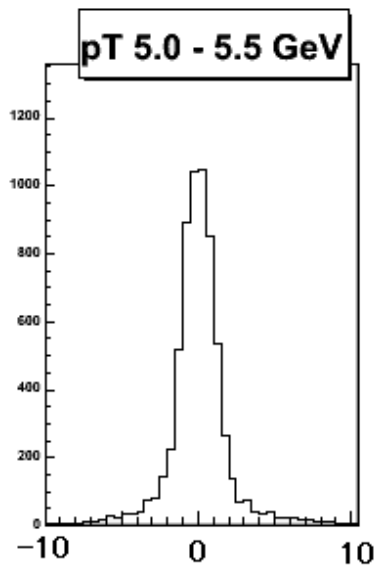


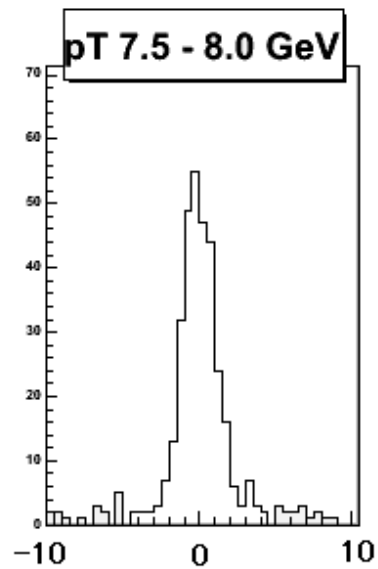


PC3sdphi with e/p > 0.3





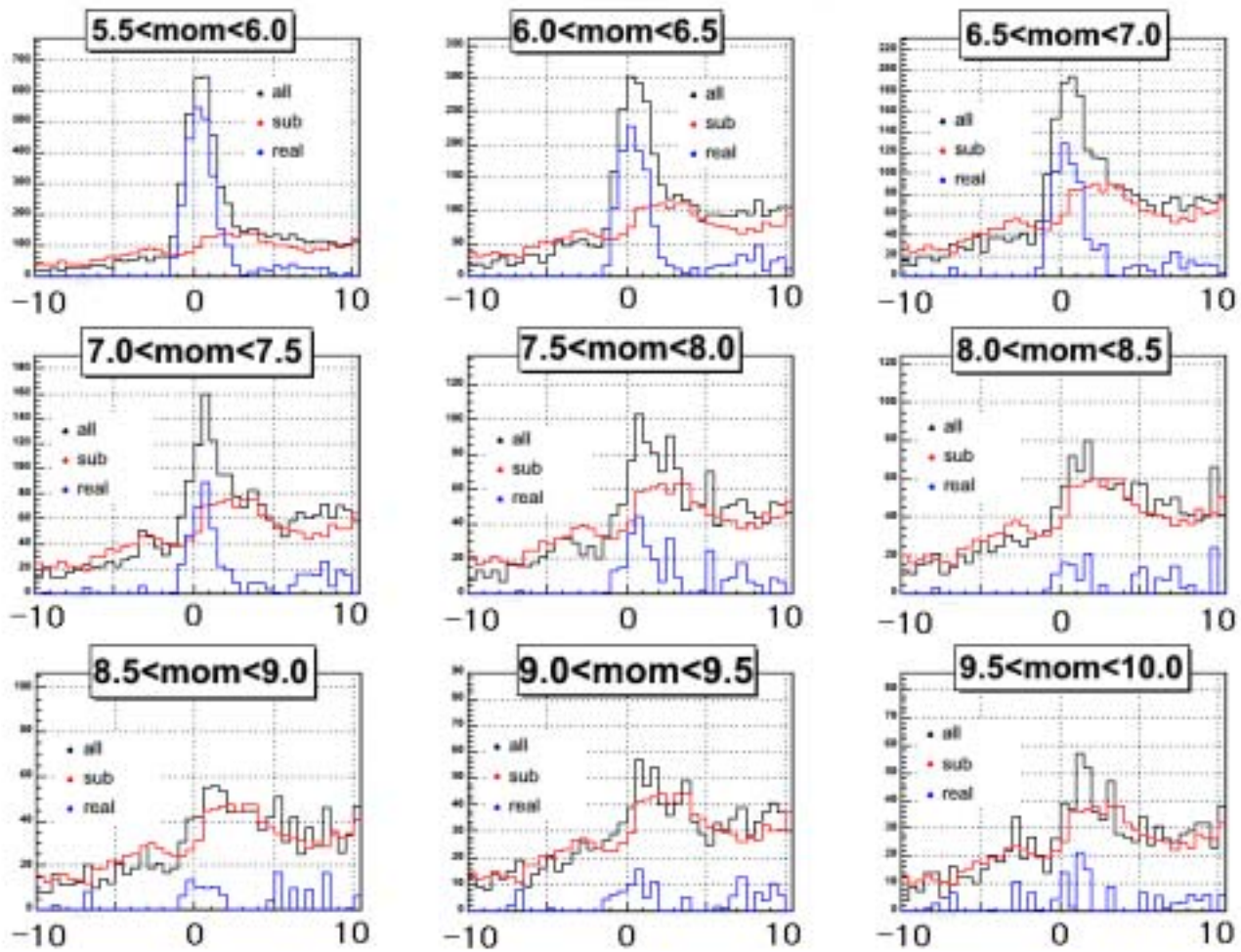




<Method 2-1>

1. Rich not fired (n0=0)

Charge + ,Min-Bias



- Black- all
- Red – BG

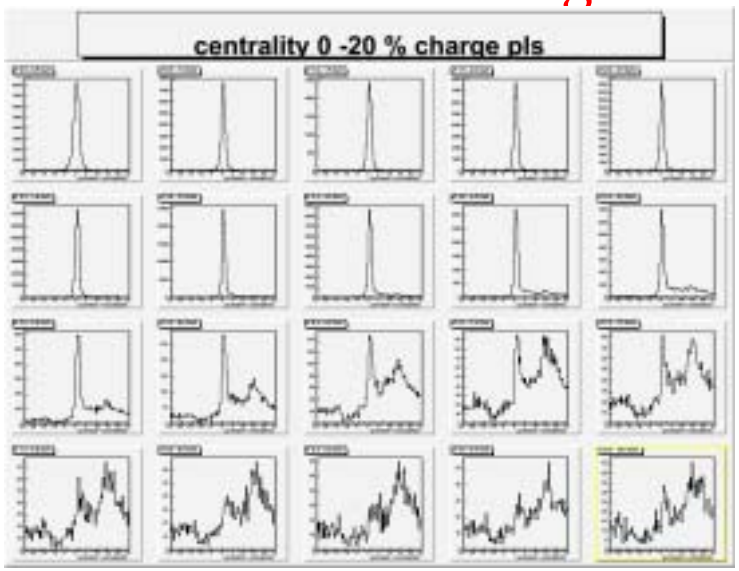
(Scaling with distribution at pT>10GeV)

- Blue- signal

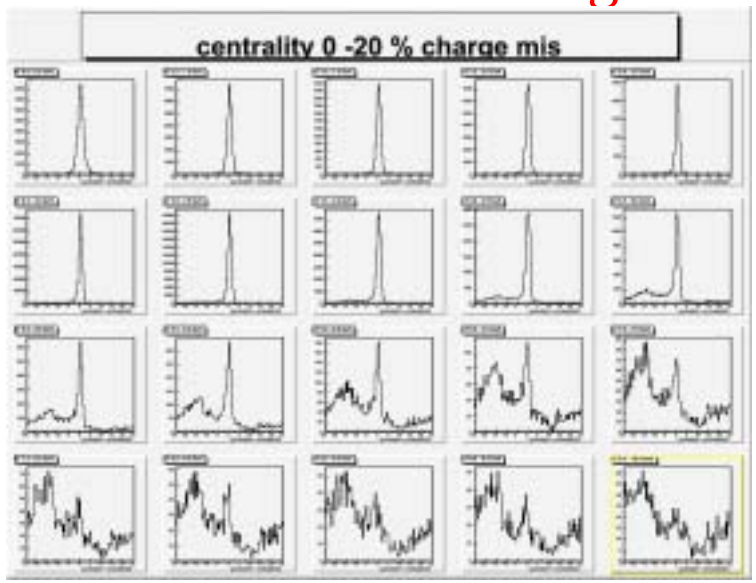
(all-BG)

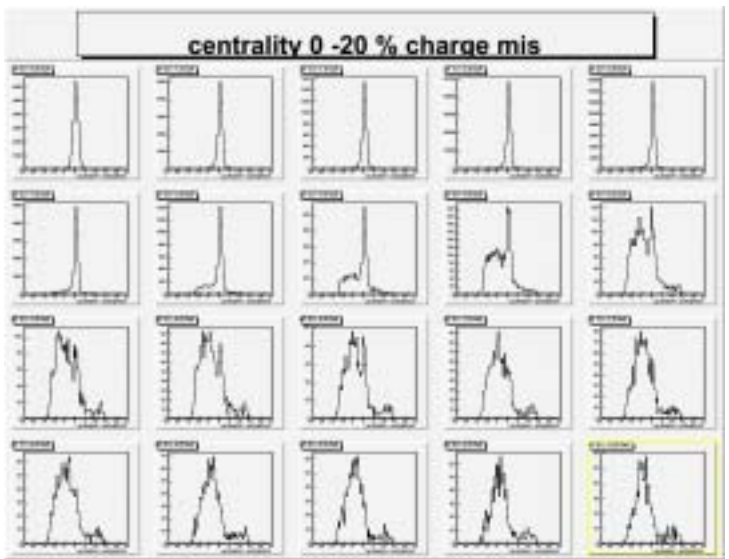
brphi distributions (Method 2)

Rich not fired charge +

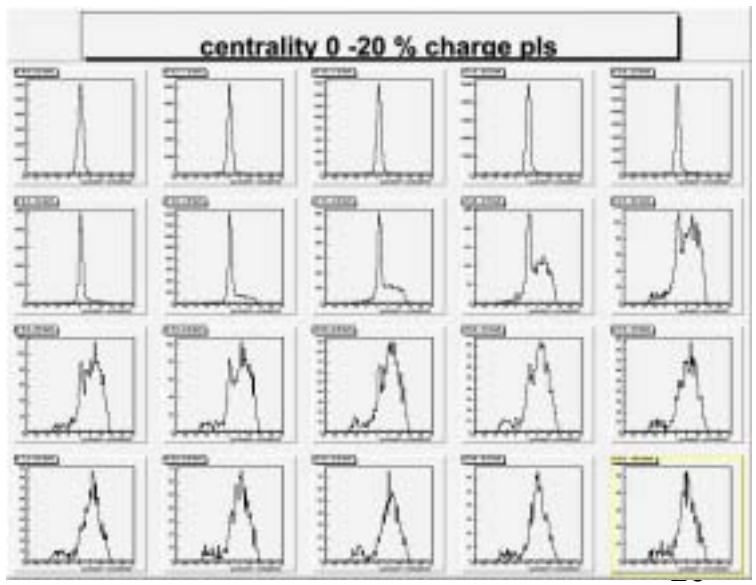


Rich not fired charge -



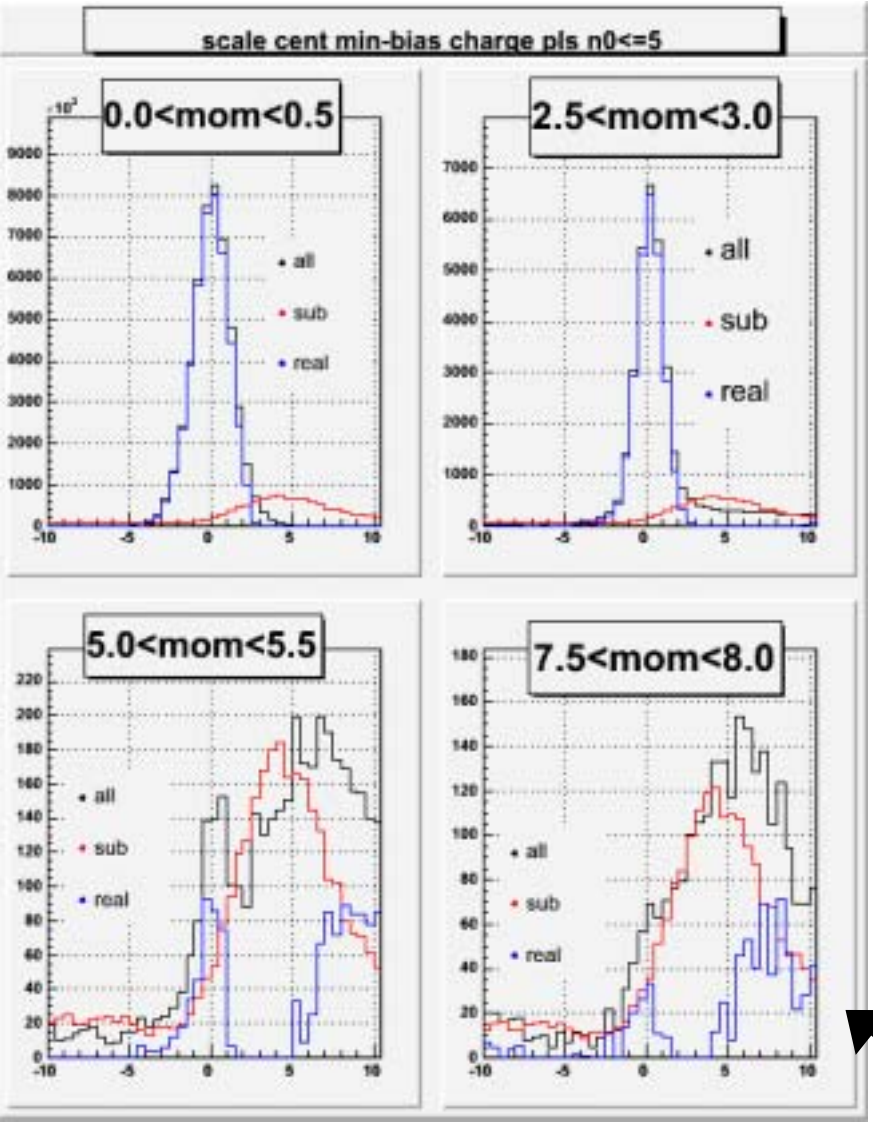


Rich fired charge -



Rich fired charge +

<Method2-2-2> 2. Rich fired



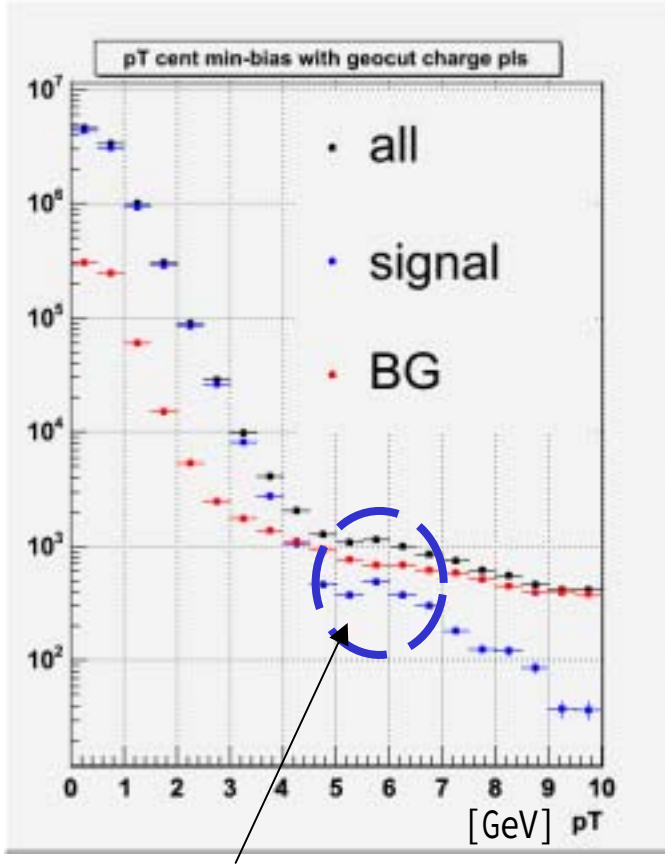
(PC2sdphi+PC3sdphi)/2

- Black- all
- Red – BG

(Scaling with distribution at pT>10GeV)

- Blue- signal

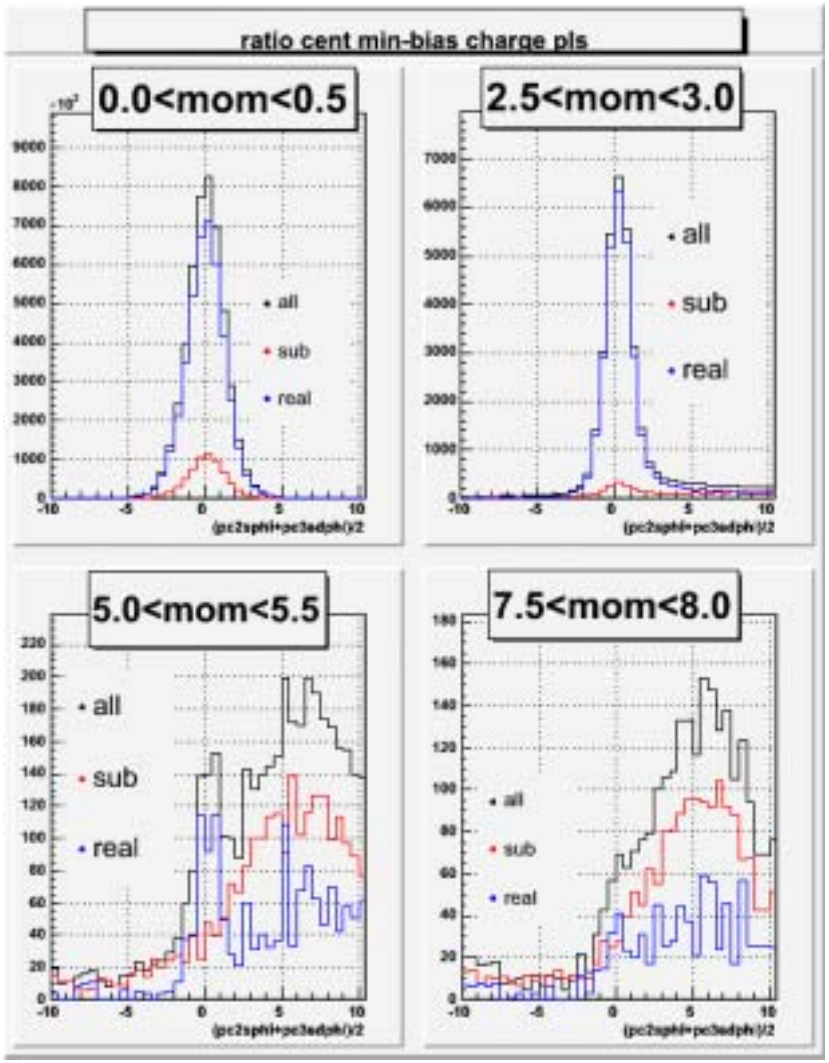
(all-BG)



Pion contribution

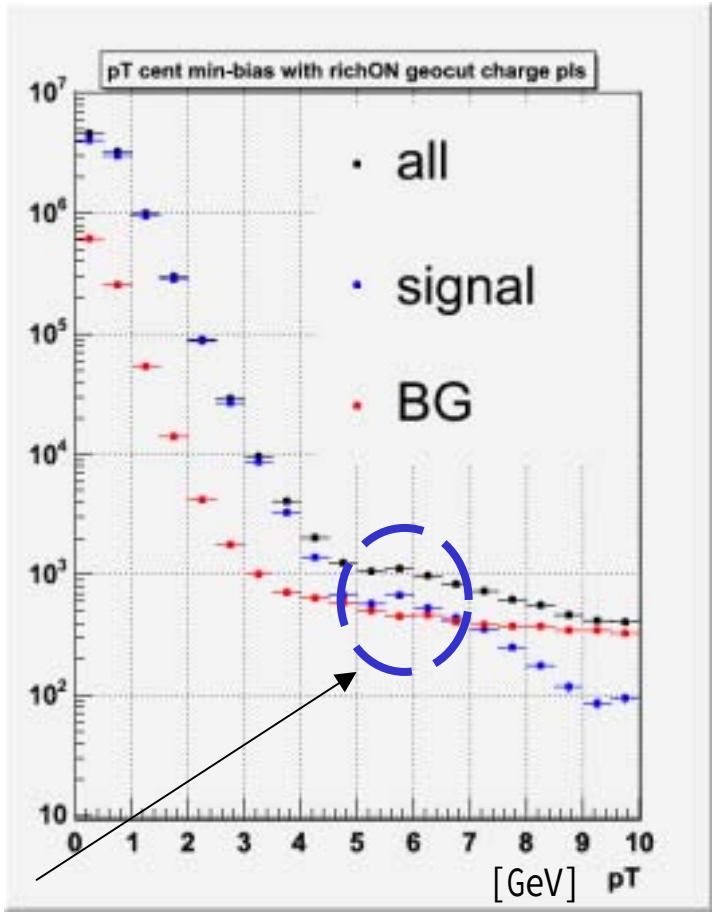
Match the heights at 4<brphi<8

<Method2-2-3> 2. Rich fired



brphi

- Black- all
- Red – BG (ratio of 0<n0<=4 to n0>4 at each pT)
- Blue- signal (all-BG)

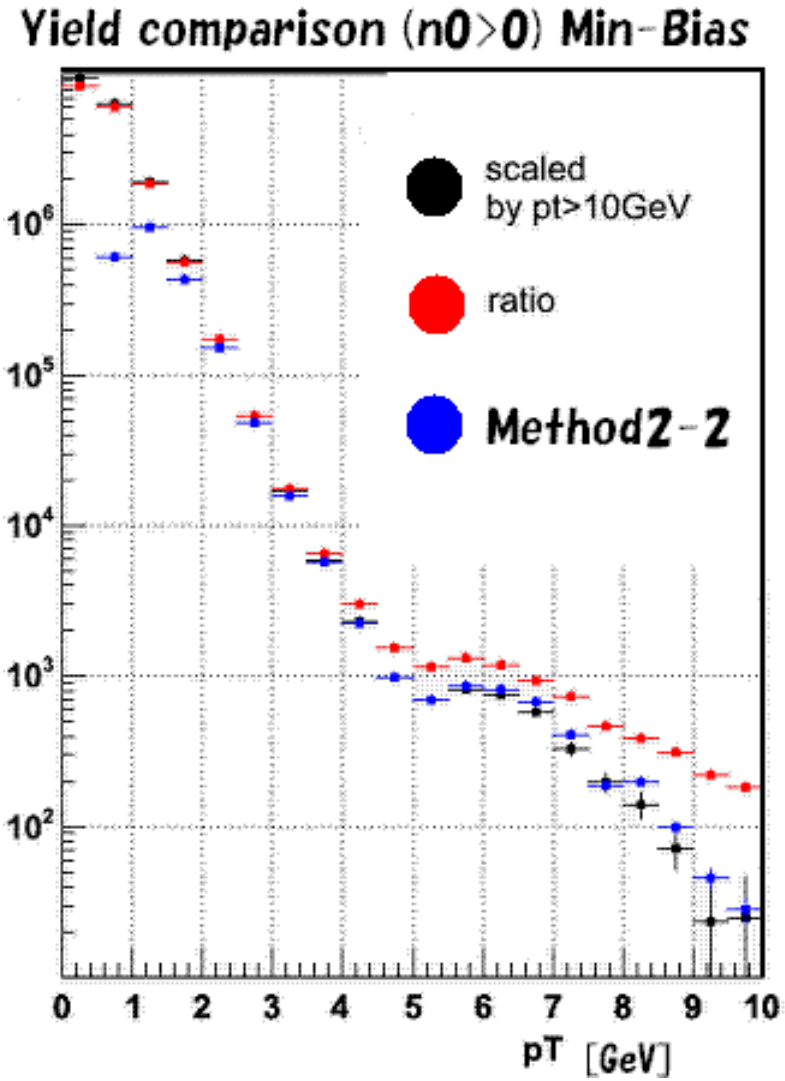


Pion contribution

$$\frac{electron_{0<n0<=4}}{electron_{n0>4}} = const$$

Comparison of the results (Rich fired)

Yield vs pT



V2 vs pT with different methods